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ABSTRACT

This manual identifies the standard skills required of a work-ready, entry-level electronics technician. It provides a valuable resource for these groups: students considering careers as electronics technicians; for counselors, educators, and administrators; and for employers. An introduction discusses use of the standards and includes two lists of duties and tasks--for the work-ready electronics technician and for the consumer electronics technician. A table shows the length of time needed in each skill category to train students to meet the standards. The rest of the manual presents the skill standards in detail, separated into five chapters. Chapter 2 covers desirable behavior and work habits, including work ethics and behavior, interpersonal relationships, and teamwork. Chapter 3 on technical skills includes general skills, DC circuits, AC circuits, discrete solid state circuits, analog circuits, digital circuits, microprocessors, and microcomputers. Chapter 4 on test equipment and tools contains standards based on the worker's ability to know and understand how the test equipment or tool works and when, where, and how to use it. Chapter 5 on basic and practical skills covers technical literacy, communicating on the job, solving problems and critical thinking, reading, and proficiency in mathematics and physics. Chapter 6 covers three skill areas that should be included in training at a level that provides a basic overview and understanding of the subject matter--communications, electromechanics, and laser applications. (YLB)

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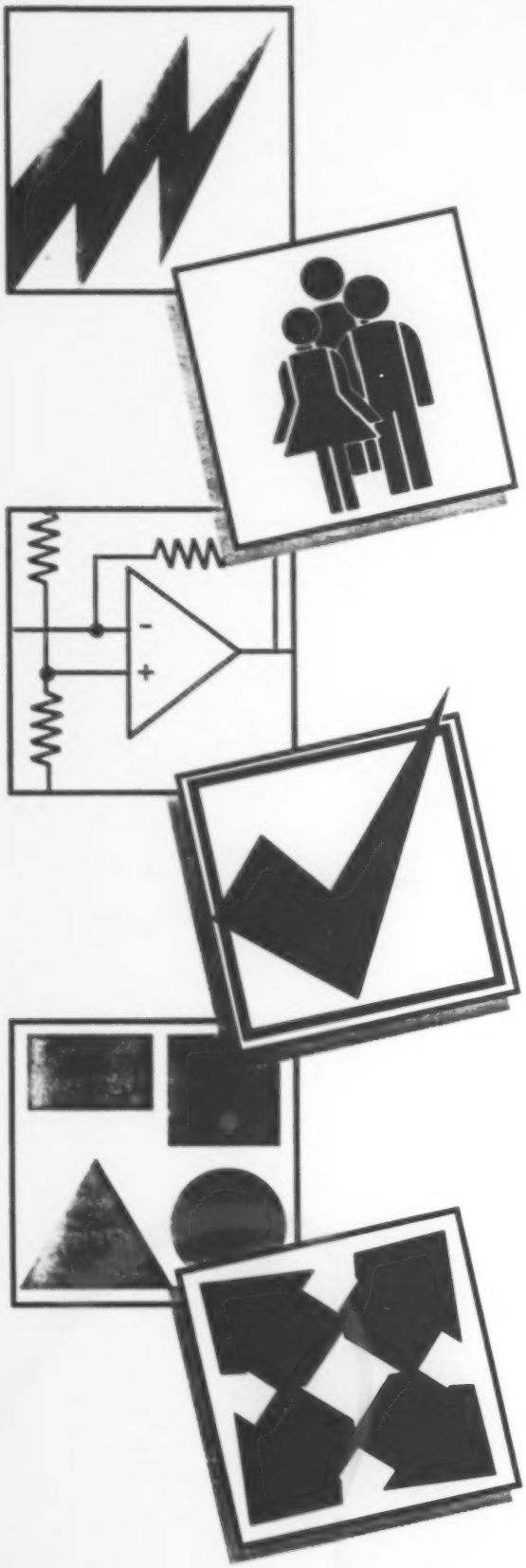

Raising the Standard

Electronics Technician Skills for Today and Tomorrow

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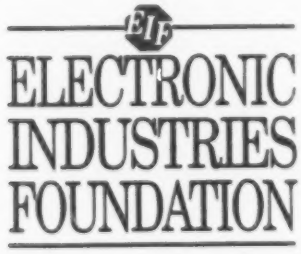

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Table of Contents

Preface 2

Acknowledgements 4

Project Leadership 5

Participating EIA Members and Other Companies 8

Participating Colleges, Institutions, Agencies 9

Introduction 1-1

Skill Standards 1-2

Duties and Tasks 1-3

Summary of Training Time Estimates 1-5

Desirable Behavior and Work Habits 2-1

Technical Skills 3-1

Test Equipment and Tools 4-1

Basic and Practical Skills 5-1

Additional Skills 6-1

EIF, the not-for-profit foundation of the Electronic Industries Association, is a tax exempt organization under Section 501(c)(3) of the Internal Revenue Code.

Preface

A battle standard provides identification and a rallying point for troops united in a common cause. These skill standards, developed to measure and promote the competency of work-ready, entry-level U.S. electronics technicians, should provide a similar rallying point for the U.S. electronics industry. They are raised to provide a single focus for students, educators, and employers; to support the nation in achieving global economic competitiveness; to help assure the industry's future; and to better enable educators to produce workers qualified to enter the field of electronics.

Why Develop Standards?

Technological superiority is key to American economic superiority. Our economic survival depends on our ability to meet globally competitive standards of manufacture and performance. We must be able to assure that our electronics equipment — be it computers, telecommunications, video and audio equipment, satellites, automated factories, space flight, CAT scanners, and sophisticated defense systems or automated teller machines, supermarket checkout scanners, cordless phones, self-regulating thermostats, and private automobiles — is superior in design, operates at full capacity, and is serviced with a minimum of down time. The high performance workplace demands a skilled, competent workforce. In just a decade, the U.S. electronics industry will represent nearly a $600 billion slice of the American economy and will require an estimated 2.5 million work-ready electronics technicians with world-class skills. These standards are meant to assure that these needs can be met.

How the Standards Were Developed

These skill standards derive from a cooperative effort between industry and government that started in 1991 with the Secretary's Commission on Achieving Necessary Skills (SCANS). In October 1992, the U.S. Department of Education's Business and Education Standards Program extended the cooperation, providing generous funding to the Electronic Industries Foundation (EIF) and its parent organization, the Electronic Industries Association (EIA), to initiate the National Skill Standards Development Project (NSSDP). The NSSDP, part of a national effort to improve American workplace standards by the year 2000, represents an intensive effort to identify, detail, and validate clusters of skills and competencies that the work-ready, entry-level technician needs to meet the demands of the U.S. electronics industry. An individual who can meet these standards will be able to enter the workforce and, with a minimum of additional specialized training, move into one of eleven specialty occupations: general electronics, avionics, business machine service, consumer product service, biomedicine, microcomputer systems, microcomputer systems field service, industrial electronics, instrumentation, telecommunications, and automobile service.

Developing standards that would meet the varied and compelling needs for them demanded the cooperation and participation of many people representing diverse disciplines and expertise. EIF and EIA were joined by the National Association of State Directors of Vocational Technical Education, the International Association of Machinists and Aerospace Workers, and a coalition of other industry, labor, and education organizations in a collaborative effort to manage the project.

More than 200 workers, supervisors, administrators, executives, and educators from approximately 100 participating companies, government agencies, institutions, unions, and associations worked side by side in meetings across the country to develop the workable, mutually agreeable standards contained in this document. They contributed to development of the standards through one of four levels of participation:

- **A Management Team** of project partners who provided direction to the project;
- An **Executive Advisory Board** of senior executives who provided oversight and guidance to the project;
- A **Technical Committee** of mid-level managers who held direct responsibility for developing the skill standards; or
- ***Ad Hoc* Groups** of technicians and their supervisors who identified skills required in each specialty area.

Working with the committee, the *ad hoc* groups identified clusters of skills and competencies that technicians need in order to perform ably the duties and tasks required of each specialty occupation. The project staff compiled and compared the skill sets for each occupation to identify those common to all or most of the specialties. These common skills formed the working draft of the skill standards.

Assuring Their Validity

Once the draft standards were assembled, their appropriateness and utility were validated against actual workplace performance. More than 1,500 company representatives, labor representatives, and educators were asked to review the draft skills and, if appropriate, to assess their importance to workplace productivity. Over 300 individuals responded to a detailed questionnaire and provided open-ended comments. Supervisors and technicians from companies that have instituted high performance work processes met in small groups to discuss the draft standards and consider the comments from questionnaire respondents. They reviewed the standards and comments in comparison to the requirements of the high performance workplace. Adjustments were made based on the findings of these analyses. Independent agencies assessed the developed standards against international benchmarks to assure that they will enable U.S. workers to meet standards set anywhere in the world. Human resources specialists reviewed the nearly final standards to assure that they were not biased as to race, sex, or ethnic background.

Satisfied that the standards had been developed out of a comprehensive review, forged in consensus among industry, government, education, and labor, and proven valid in the workplace, the NSSDP Executive Advisory Board submitted them to the Electronic Industries Association Board of Governors, which ratified their adoption in March 1994.

Taking the Lead

Just after the skill standards were ratified, also in March 1994, Congress passed and the President signed the Goals 2000 Educate America Act, which includes creation of a National Skill Standards Board. With its enactment, government reinforces the importance of high quality vocational training for the over 75 percent of young people who will not complete a four-year college degree. The act emphasizes the need, as President Clinton has said, "... to merge the world of learning with the world of work. . . ."

These consistent, industry-based voluntary standards are meant to encourage excellence in vocational education to improve the American workforce. They clarify the competencies needed for job performance; meet employers' needs by improving workers' capabilities and productivity; and enhance a company's ability to convert its operations to a high performance workplace. They enable educators to develop performance-based curricula preparing graduates to leave school with work-ready skills, qualified to obtain jobs, to hold jobs successfully, to change jobs within broad occupational areas, and to adapt to changes brought about by emerging new technologies.

EIA and EIF, on behalf of the electronics industry, are pleased to take the lead in presenting these skill standards. They support the merger of education and employment by giving workers academic and occupational skills for a lifetime of work.

Acknowledgements

The National Skill Standards Development Project is a truly cooperative effort in which industry, labor, education, and government representatives have given freely of their time and expertise to plan, develop, and validate the skill standards for the work-ready, entry-level electronics technician. Over 200 people have been directly involved in this process and over 300 additional people contributed by responding to questionnaires used as part of the development and validation process. Following this acknowledgment, the reader will find the names and affiliations of the members of the project's Management Team, Executive Advisory Board, and Technical Committee and the names of the companies, schools, institutions, and agencies whose employees have contributed to the project by participating in the *ad hoc* groups, the focus groups, or by responding to the project questionnaires. I thank you all.

There are several people who served on the bodies mentioned above who deserve special recognition. Frank Myers, chairman and CEO of Wells-Gardner Electronics, chaired the Executive Advisory Board and served as liaison to the Electronic Industries Association Board of Governors. William Berg provided leadership to the Technical Committee until his retirement as general manager, Service Administration Division, Matsushita Electric Corporation of America. He was ably followed by Mike Brooks, director of Technical Service of Philips Consumer Electronics. Don Hatton, staff vice president of product services in the Consumer Electronics Group of the Electronic Industries Association, was always available to discuss and resolve issues and provided invaluable assistance as a member of the Management Team. Wayne Freeland, manager, Job Enhancement Programs, Non-Exempt Training, for Texas Instruments, raised the standard for everyone when he volunteered to develop and lead the initial *Ad Hoc* Task Group in the Dallas area. This task group, with over 60 participants representing seven occupational specialties, was key to the successful completion of this project. Don Eshelby of the Idaho Division of Vocational Education, Terrance (Butch) Miller of Kenwood U.S.A., and Bill Callahan of the California Department of Education also provided significant assistance organizing, planning, and operating *ad hoc* task groups.

I also wish to acknowledge the contributions of William Boss and Dr. Barbara Border, consultants to the project; Dr. Charles Losh, the project's summative evaluator; Jim Magee, Tim Farr, and Bob Mills of EIF and Walt Seymour of EIA, who provided invaluable assistance during those crunch periods all projects encounter; and Tom O'Brien and Margaret Gordetsky, my assistants during this effort. I give my special thanks to Molly M. Mannon, president of EIF, for providing me the opportunity to lead this important effort and for the guidance she provided, and to Joan Hartman Moore, whose editing has significantly improved the project's documentation.

Finally, but not in the least, I wish to acknowledge Peter F. McCloskey, president of EIA, for his personal interest and support of the project, and Debra Nolan and Carolyn Lee, the U.S. Department of Education program advisors, for their continuing support.

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Participants in the NSSDP are developing measurement criteria for the skill standards shown in this manual. They should be available by the first quarter of 1995. To receive a copy please contact EIF or return the enclosed card.

Participating EIA Members and Other Companies

Companies in **BOLD** are Electronic Industries Association Members

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Agoada Electronic Service
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Alphatech Electronics
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Apple Computer, Incorporated
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AT&T
Avenue Radio & TV
Avital Technologies, Inc.
Banner Engineering
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Beaver Office Products Inc.
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Casio Incorporated
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Cincinnati Electronics Corporation
Circuit City Stores, Inc.
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Consumer Video Service
Cornell Dubilier Electronics
Cray Research, Incorporated
CTI Technologies Inc.
Dallas Premier Television
DBA Communications Systems, Incorporated
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Delco Electronics Corporation
Denon America, Incorporated
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Edmonston Electronics
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ENI
ER&G Idaho
ERS Technologies
ESM
Eugene's Carry-In
Eveready Battery Co., Inc.
EXPERTECH, Inc.
Gaufre Electronics
General Cable Company
Genrad
Glass Antenna Service
Glass Antenna Systems, Inc.
Goldstar Electronics International, Incorporated
Go-Video, Incorporated
Grass Valley Group, Incorporated
GTE Corporation
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Herby's Electronics
Hewlett-Packard Company
High Tech Video Service
Hitachi America, Limited
Hodges Electronics
Hurco Manufacturing Company
Interlink
International Business Machines Corporation
Illinois Capacitor, Incorporated
Integrated Technology Corporation
Intel Corporation
ISU Electronics
ITT Corporation
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J.W. Griffin Company
Jet Process Corporation
Johnson TV Service Center
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JVC Service and Engineering Company
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Lemmon's TV Service
Leonard Smith Electronics Inc.
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M&D Electronics
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McCann Electronics
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McKenzie Development Corp.
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Video Revolution
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Upper Valley Joint Vocational School
Vocational Industrial Clubs of America
Wadena Technical College
Wake Technical Community College
Western Technical Institute
Willmar Technical College
Wisconsin Indianhead Technical College
Worcester Technical Institute

Introduction

Introduction

This manual identifies the standard skills required of a work-ready, entry-level electronics technician. It provides a valuable resource for students considering careers as electronics technicians; for counselors, educators, and academic administrators who prepare them for electronics careers; and for employers who depend on the vitality and capability of a well-trained workforce to supply the modern electronics demanded by American society. They can use it in a variety of ways.

- **Students.** A review of these standards can help students decide whether to pursue careers as electronics technicians. The standards indicate what basic course work they should have taken and what knowledge base and skills they will need before they undertake the required technical education and training.

- **School Counselors.** The standards can help counselors evaluate and advise students regarding their potential to successfully complete electronics technician training and work as electronics technicians. They can help counselors guide students in completing prerequisites to training.

- **Educators and Trainers.** These standards provide detailed information that can be used to develop appropriate training curriculum content. They create an objective basis for discussing training content with local employers.

- **Educational Administrators.** The standards provide a basis for planning, requesting resources, and developing and incorporating innovative training approaches into programs. They offer a means for approaching electronics companies for cooperation and participation in developing and implementing plans and training programs.

- **Employees and Employers.** Job candidates trained to meet the standards can assure prospective employers of their competency. Employers can use the standards as a criterion for hiring. As more new workers meet the standards, employers can direct corporate training resources to develop employee skills and knowledge tailored to company needs not to remediate basic education and training. Employers can use the standards to develop programs with local schools that meet specific company needs.

A majority of students studying to become electronics technicians do not successfully complete their training. In part, they have difficulty understanding basic math and science and have not acquired the prerequisite knowledge they need, before they begin, to complete training successfully. Students should receive adequate counseling and preparation before being permitted to enter training.

Skill Standards

The work performed by many electronics technicians, although broad in scope, revolves around a finite number of activities, including installing, maintaining, and repairing equipment; evaluating needs; troubleshooting problems; and administering work. These tasks are performed in laboratories, plants, businesses, and homes. Many other technicians provide support for manufacturing or engineering in the development and testing of components, products, and procedures.

This manual lists the skills a technician needs to master to work in any of these settings and to perform any of these duties and tasks. In fact, the standards are based upon a detailed analysis of the duties an electronics technician is expected to perform and a breakdown of each duty into the specific tasks required for its performance. This section includes two lists of duties and tasks: the first is for the work-ready, entry-level electronics technician; the second, included as an example of specialty skills, is for the consumer electronics technician. The basic skills form the underpinnings for additional knowledge, skills, and techniques — including knowledge of equipment and techniques specific to one of the eleven specialties — not identified in detail here but required for work in some of the specialties. For example, an avionics technician would be expected to know flight dynamics and hydraulics in detail and to understand the specialized equipment used to measure and evaluate the complex circuits that provide the flight controls. Likewise, a biomedical technician would be expected to understand physiology and the workings of specialized biomedical equipment such as blood gas analyzers and sophisticated x-ray devices.

Experienced electronics instructors have estimated the time needed, by skill category, to train students to meet the standards. These times are shown in a table at the end of this section and in each of the following chapters.

The rest of the manual presents the skill standards in detail, separated into five chapters: Desirable Behaviors and Work Habits, Technical Skills, Test Equipment and Tools Skills, Basic and Practical Skills, and Additional Skills. The first chapter covers employee attributes critical to worker productivity but difficult to measure objectively. We lead off with them because they are so important to the worker's overall employability and success, even though they cannot be easily measured and thus cannot be counted among the actual standards. If and when objective measurements are developed, we will make every effort to bring these attributes into the main body of standards.

Electronics technology changes rapidly and continually, making it difficult for instructors to keep up with the field. Companies and schools should create joint programs to enable instructors to stay current. Companies can enroll teachers in industry training classes or in-service training through short-term, industry-based work assignments; educational and training institutions can provide incentives that enable and encourage instructors to participate..

Duties and Tasks

Work-Ready, Entry-Level Electronics Technician

Duty Area: Installation

Tasks: Install equipment per customer requirements

Initialize equipment per specification

Calibrate equipment per specification

Provide operational instructions and training

Duty Area: Maintenance

Tasks: Clean electrical connections

Calibrate as required

Tune process instrumentation and control systems

Clean or replace filters

Test for correct operation

Duty Area: Evaluation and Troubleshooting

Tasks: Evaluate electronic equipment per specification

Determine that functional requirements are met

Troubleshoot electronic equipment

To assembly level

To board level

To component level

Duty Area: Repair

Tasks: Repair and test electronic equipment to specification

At assembly level

At board level

At component level

Upgrade electronic equipment per specifications

Duty Area: Manufacturing/Engineering Support

Tasks: Understand project requirements

Develop prototype or procedure

Test/evaluate and modify prototype or procedure

Test/evaluate manufactured components or products

Duty Area: Administration

Tasks: Record work performed

Use reference manuals to perform specific functions

Prepare service bills

Prepare machine maintenance reports

Communicate with customer

Instruct customer as to proper application of equipment

Instruct customer as to proper operation of equipment

Ensure customer satisfaction

Duties and Tasks

Consumer Electronics

Duty Area: Bench Technician

Tasks: Accept unit for work

Verify customer complaint

Recognize symptoms

Troubleshoot - Identify defective component(s)

Develop estimate for customer

Remove and replace defective part(s)

Complete equipment repair and reassembly

Conduct operational and safety checks

Complete paperwork and return to customer

Confirm customer acceptance and satisfaction with repair

Duty Area: Field Technician

Tasks: Organize service vehicle

Conduct pre-diagnostics

Travel to customer location

Verify customer complaint

Recognize symptoms

Troubleshoot - Identify defective component(s) and determine service location

Develop estimate for customer

Remove and replace defective part(s)

Complete equipment repair and reassembly

Conduct operational and safety checks

Complete paperwork and return to customer

Confirm customer acceptance and satisfaction with repair

Summary of Training Time Estimates

Technical Skills	1200 to 1620 hours
Test Equipment and Tools	50 to 100 hours
Basic and Practical Skills	250 to 350 hours
Additional Skills	65 to 105 hours
TOTAL	1565 to 2175 hours

Good employees demonstrate desirable traits and work habits unrelated to technical competency but equally important, for example, respect for co-workers, working well with others, capability for leadership, honesty, and reliability. Methods should be developed to teach and evaluate these traits. However, school transcripts do not cover behaviors, so internships or apprenticeships may be necessary to evaluate work habits and make the findings available.

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Desirable Behavior and Work Habits

A. Work Ethics and Behavior

Estimated training time: Integral to all training.

A.01 Implement responsibilities of job position including exhibiting dependability and meeting organizationally defined expectations

A.02 Follow rules, regulations and policies as established including interpreting employer/employee handbook and procedures

A.03 Understand and practice cost effectiveness

A.04 Practice time management and follow work schedule

A.05 Assume responsibility for own decisions and actions

A.06 Exhibit pride

A.07 Display initiative in undertaking new tasks

A.08 Show assertiveness appropriate to the situation

A.09 Seek work challenges

A.10 Understand and apply ethical principles to decisionmaking

A.11 Comply with company standards including dress, personal hygiene and cleanliness

A.12 Understand the importance of providing good customer service (internal and external)

B. Interpersonal Relationships

B.01 Respond constructively to suggestions for improvement

B.02 Provide praise and suggestions for improvement

B.03 Channel/control emotional reactions constructively

B.04 Recognize problems and work toward their solution

B.05 Exhibit positive behavior

B.06 Exhibit sensitivity to internal and external customer needs

B.07 Treat people with respect

B.08 Recognize non-verbal communication

C. Teamwork

C.01 Understand interactive relationships required for effective teamwork

C.02 Understand team's operating procedures

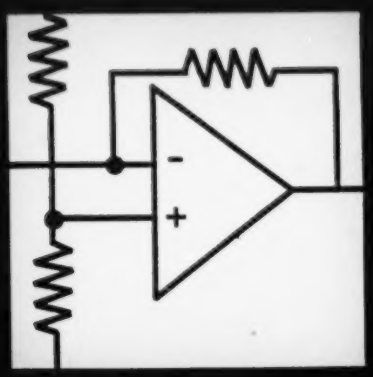
C.03 Adapt as necessary to complete the team task

C.04 Evaluate outcome

The standards in this section are based upon the worker's ability to know the technical basis for and be able to explain how a product, device, circuit, or procedure works; to be able to apply that knowledge; and, as appropriate, to fabricate, demonstrate, troubleshoot, repair, or replace the product, device, or circuit.

Included in Technical Skills are

A. General Skills
B. DC Circuits
C. AC Circuits
D. Discrete Solid State Circuits
E. Analog Circuits
F. Digital Circuits
G. Microprocessors
H. Microcomputers



Technical Skills

Technical Skills

Equipment and materials for electronics training can be expensive. Companies should become involved in technical education at the policy, planning, and budgeting levels to validate needs and act as advocates for the schools and school systems. Companies should try to provide equipment and materials or allow access to theirs.

A. General

Estimated training time: 50 to 70 hours

A.01 Demonstrate an understanding of proper safety techniques for all types of circuits and components (DC circuits, AC circuits, analog circuits, digital circuits, discrete solid-state circuits, microprocessors)

A.02 Demonstrate an understanding of and comply with relevant OSHA safety standards

A.03 Demonstrate an understanding of proper troubleshooting techniques

A.04 Demonstrate an understanding of basic assembly skills using hand and power tools

A.05 Demonstrate an understanding of acceptable soldering/desoldering techniques, including through-hole and surface mount devices

A.06 Demonstrate an understanding of proper solderless connections

A.07 Demonstrate an understanding of use of data books and cross reference/technical manuals to specify and requisition electronic components

A.08 Demonstrate an understanding of the interpretation and creation of electronic schematics, technical drawings, and flow diagrams

A.09 Demonstrate an understanding of design curves, tables, graphs, and recording of data

A.10 Demonstrate an understanding of color codes and other component descriptors

A.11 Demonstrate an understanding of site electrical and environmental survey

A.12 Demonstrate the use of listening skills or assistive devices to assess signs and symptoms of malfunctions

B. DC Circuits

Estimated training time: 150 to 200 hours

B.01 Demonstrate an understanding of sources of electricity in DC circuits

B.02 Demonstrate an understanding of principles and operation of batteries

B.03 Demonstrate an understanding of the meaning of and relationships among and between voltage, current, resistance and power in DC

B.04 Demonstrate an understanding of measurement of resistance of conductors and insulators and the computation of conductance

B.05 Demonstrate an understanding of application of Ohms Law to series, parallel and series-parallel circuits

B.06 Demonstrate an understanding of magnetic properties of circuits and devices

B.07 Demonstrate an understanding of the physical, electrical characteristics of capacitors and inductors

B.08 Understand principles and operations of DC series circuits

B.09 Fabricate and demonstrate DC series circuits

B.10 Troubleshoot and repair DC series circuits

B.11 Understand principles and operations of DC parallel circuits

B.12 Fabricate and demonstrate DC parallel circuits

B.13 Troubleshoot and repair DC parallel circuits

B.14 Understand the principles and operations of DC series-parallel and bridge circuits

B.15 Fabricate and demonstrate DC series-parallel and bridge circuits

B.16 Troubleshoot and repair DC series-parallel and bridge circuits

B.17 Understand the principles and operations of the Wheatstone Bridge

B.18 Understand principles and operations of DC voltage divider circuits (loaded and unloaded)

B.19 Fabricate and demonstrate DC voltage divider circuits (loaded and unloaded)

B.20 Troubleshoot and repair DC voltage divider circuits (loaded and unloaded)

B.21 Understand principles and operations of DC RC and RL circuits

B.22 Fabricate and demonstrate DC RC and RL circuits

B.23 Troubleshoot and repair DC RC and RL circuits

B.24 Demonstrate an understanding of measurement of power in DC circuits

C. AC Circuits

Estimated training time: 175 to 250 hours

C.01 Demonstrate an understanding of sources of electricity in AC circuits

C.02 Demonstrate an understanding of the properties of an AC signal

C.03 Demonstrate an understanding of the principles of operation and characteristics of sinusoidal and non-sinusoidal wave forms

C.04 Demonstrate an understanding of basic motor/generator theory and operation

C.05 Demonstrate an understanding of measurement of power in AC circuits

C.06 Demonstrate an understanding of the principle and operation of various power conditioning: (isolation transformers, surge suppressors, uninterruptable power systems)

C.07 Demonstrate an understanding of the principle and operation of safety grounding systems: (lightning arresters, ground fault interrupters, etc.)

C.08 Understand principles and operations of AC capacitive circuits

C.09 Fabricate and demonstrate AC capacitive circuits

C.10 Troubleshoot and repair AC capacitive circuits

C.11 Understand principles and operations of AC inductive circuits

C.12 Fabricate and demonstrate AC inductive circuits

C.13 Troubleshoot and repair AC inductive circuits

C.14 Understand principles and operations of AC circuits using transformers

C.15 Demonstrate an understanding of impedence matching theory

C.16 Fabricate and demonstrate AC circuits using transformers

C.17 Troubleshoot and repair AC circuits using transformers

C.18 Understand principles and operations of AC differentiator and integrator circuits (determine RC and RL time constants)

C.19 Fabricate and demonstrate AC differentiator and integrator circuits

C.20 Troubleshoot and repair AC differentiator and integrator circuits

C.21 Understand principles and operations of AC series and parallel resonant circuits

C.22 Fabricate and demonstrate AC series and parallel resonant circuits

C.23 Troubleshoot and repair AC series and parallel resonant circuits

C.24 Understand principles and operations of AC RC, RL, and RLC circuits

C.25 Fabricate and demonstrate AC RC, RL, and RLC circuits

C.26 Troubleshoot and repair AC RC, RL, and RLC circuits

Many entry-level workers have difficulty troubleshooting a device to identify and locate a problem. They do not seem to understand what needs to be done, where to start, or how to proceed. Mastery of troubleshooting techniques as specifically defined in the skill standards should be incorporated into training.

C.27 Understand principles and operations of AC frequency selective filter circuits

C.28 Fabricate and demonstrate AC frequency selective filter circuits

C.29 Troubleshoot and repair AC frequency selective filter circuits

C.30 Understand principles and operations of AC polyphase circuits

C.31 Understand principles and operations of AC phase locked loop circuits

C.32 Troubleshoot and repair AC phase locked loop circuits

D. Discrete Solid State Devices

Estimated training time: 175 to 250 hours

D.01 Demonstrate an understanding of the properties of semiconductor materials

D.02 Demonstrate an understanding of PN junctions

D.03 Demonstrate an understanding of bipolar transistors

D.04 Demonstrate an understanding of field effect transistors (FET's/MOS-FET's)

D.05 Demonstrate an understanding of special diodes and transistors

D.06 Understand principles and operations of diode circuits

D.07 Fabricate and demonstrate diode circuits

D.08 Troubleshoot and repair diode circuits

D.09 Understand principles and operations of optoelectronic circuits (gate isolators, interrupt sensors, infra red sensors, etc.)

D.10 Fabricate and demonstrate optoelectronic circuits (gate isolators, interrupt sensors, infra-red sensors, etc.)

D.11 Troubleshoot and repair optoelectronic circuits (gate isolators, interrupt sensors, infra-red sensors, etc.)

D.12 Understand principles and operations of single stage amplifiers

D.13 Fabricate and demonstrate single stage amplifiers

D.14 Troubleshoot and repair single stage amplifiers

D.15 Understand principles and operations of thyristor circuitry (SCR, TRIAC, DIAC, etc.)

D.16 Fabricate and demonstrate thyristor circuitry (SCR, TRIAC, DIAC, etc.)

D.17 Troubleshoot and repair thyristor circuitry (SCR, TRIAC, DIAC, etc.)

E. Analog Circuits

Estimated training time: 150 to 200 hours

E.01 Understand principles and operations of multistage amplifiers

E.02 Fabricate and demonstrate multistage amplifiers

E.03 Troubleshoot and repair multistage amplifiers

E.04 Understand principles and operations of IF circuits

E.05 Fabricate and demonstrate IF circuits

E.06 Troubleshoot and repair IF circuits

E.07 Understand principles and operations of linear power supplies and filters

E.08 Fabricate and demonstrate linear power supplies and filters

E.09 Troubleshoot and repair linear power supplies and filters

E.10 Understand principles and operations of operational amplifier circuits

E.11 Fabricate and demonstrate operational amplifier circuits

E.12 Troubleshoot and repair operational amplifier circuits

E.13 Understand principles and operations of audio power amplifiers

E.14 Fabricate and demonstrate audio power amplifiers

E.15 Troubleshoot and repair audio power amplifiers

E.16 Understand principles and operations of regulated and switching power supply circuits

E.17 Troubleshoot and repair regulated and switching power supply circuits

E.18 Understand principles and operations of active filter circuits

E.19 Troubleshoot and repair active filter circuits

E.20 Understand principles and operations of sinusoidal and non-sinusoidal oscillator circuits

E.21 Troubleshoot and repair sinusoidal and non-sinusoidal oscillator circuits

E.22 Understand principles and operations of fiber optic circuits using photodiodes or LASERS

E.23 Troubleshoot and repair fiber optic circuits using photodiodes or LASERS

E.24 Understand principles and operations of RF circuits

E.25 Fabricate and demonstrate RF circuits

E.26 Troubleshoot and repair RF circuits

E.27 Understand principles and operations of signal modulation systems (AM, FM, stereo)

E.28 Troubleshoot and repair signal modulation systems (AM, FM, stereo)

E.29 Demonstrate an understanding of motor phase shift control circuits

E.30 Understand the principles and operations of microwave circuits

F. Digital Circuits

Estimated training time: 250 to 300 hours

F.01 Demonstrate an understanding of the characteristics of integrated circuit (IC) logic families

F.02 Demonstrate an understanding of minimizing logic circuits using Boolean operations

F.03 Understand principles and operations of linear integrated circuits

F.04 Troubleshoot and repair linear integrated circuits

F.05 Understand principles and operations of types of logic gates

F.06 Fabricate and demonstrate types of logic gates

F.07 Troubleshoot and repair types of logic gates

F.08 Understand principles and operations of combinational logic circuits

F.09 Fabricate and demonstrate combinational logic circuits

F.10 Troubleshoot and repair combinational logic circuits

F.11 Understand principles and operations of types of flip-flop circuits

F.12 Fabricate and demonstrate types of flip-flop circuits

F.13 Troubleshoot and repair flip-flop circuits

F.14 Understand principles and operations of types of registers and counters

F.15 Fabricate and demonstrate types of registers and counters

F.16 Troubleshoot and repair types of registers and counters

F.17 Understand principles and operations of clock and timing circuits

F.18 Fabricate and demonstrate clock and timing circuits

F.19 Troubleshoot and repair clock and timing circuits

F.20 Understand principles and operations of types of arithmetic-logic circuits

F.21 Troubleshoot and repair types of arithmetic-logic circuits

F.22 Understand principles and operations of types of multiplexer and demultiplexer circuits

F.23 Troubleshoot and repair types of multiplexer and demultiplexer circuits

F.24 Understand principles and operations of types of digital to analog and analog to digital circuits

F.25 Troubleshoot and repair types of digital to analog and analog to digital circuits

F.26 Understand principles and operations of types of digital display circuits

F.27 Troubleshoot and repair types of digital display circuits

F.28 Understand principles and operations of power distribution noise problems

F.29 Troubleshoot and repair power distribution noise problems

F.30 Understand principles and operations of types of digital encoders and decoders

F.31 Troubleshoot and repair types of digital encoders and decoders

F.32 Understand principles and operations of digital display devices

F.33 Troubleshoot and repair digital display devices

G. Microprocessors

Estimated training time: 150 to 200 hours

G.01 Demonstrate an understanding of microprocessor interfaces

G.02 Troubleshoot and repair microprocessor interfaces

G.03 Demonstrate an understanding of essential microprocessor components

G.04 Demonstrate an understanding of microprocessor BUS concepts

G.05 Demonstrate an understanding of microprocessor components and terminology

G.06 Understand principles and operation of types of microprocessor memory circuits

G.07 Troubleshoot and repair types of microprocessor memory circuits

G.08 Understand principles and operations of Microprocessor machine code and instruction sets

H. Microcomputers

Estimated training time: 100 to 150 hours

H.01 Demonstrate an understanding of microcomputer operating systems

H.02 Demonstrate an understanding of essential microcomputer components

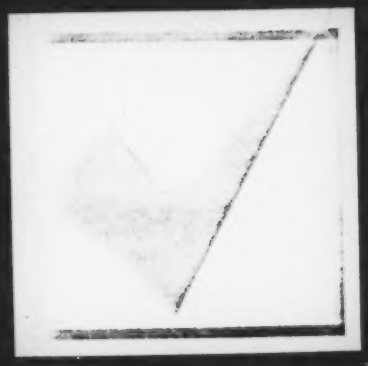
H.03 Demonstrate an understanding of microcomputer peripherals

H.04 Set up and configure a microcomputer using available operating systems and software packages

H.05 Troubleshoot and replace microcomputer peripherals

Many students are being taught on obsolete equipment. They should have access to state-of-the-art test equipment and should learn on the same technologies they will see in the workplace. For example, they need to use printed circuits in place of "breadboards."

The standards in this section are based upon the worker's ability to know and understand how the test equipment or tool works and when, where, and how to use it.



Test Equipment and Tools

Test Equipment and Tools

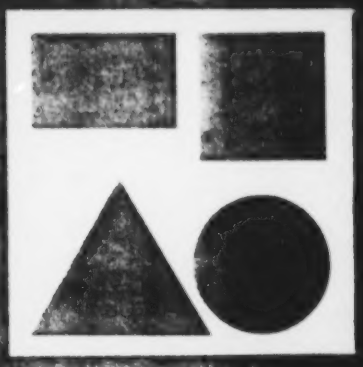
Estimated training time: 50 to 100 hours (in addition to technical training)

01 Breakout box
02 Calibration standards
03 Capacitor/inductor analyzer
04 Current probe
05 DC power source
06 Digital storage oscilloscope
07 Dummy load
08 Electrical field strength meter
09 Electrical resistance insulation tester
10 Electrostatic discharge meter (ESD)
11 Frequency counter
12 Function generator
13 Ground fault testers
14 Hand tools
15 High potential testers
16 Isolation transformer
17 LASER power meter
18 Light intensity meter
19 Logic analyzer
20 Logic probe
21 Logic pulser
22 Multimeters (digital and analog)
23 Oscilloscope
24 Power tools
25 Pressure gauges
26 RF power meter
27 RF signal generator
28 Semiconductor tester
29 Soldering/desoldering equipment and supplies
30 Soldering/desoldering equipment and supplies for surface mount devices (SMD)
31 Spectrum analyzer
32 Temperature transducer
33 Torque measuring tools
34 Vacuum gauges
35 Voltage Isolation Transformer (adjustable)

The standards in this section are based upon the worker's ability to perform a process or apply knowledge.

Included in Basic and Practical Skills are:

A. Technical Literacy
B. Communicating on the Job
C. Solving Problems and Critical Thinking
D. Reading
E. Proficiency in Mathematics
F. Proficiency in Physics



Basic and Practical Skills

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Basic and Practical Skills

Estimated training time: 250 to 350 hours

A. Technical Literacy

A.01 Demonstrate basic keyboarding skills

A.02 Demonstrate ability to use standard applications software such as word processors, database management, and spreadsheets

A.03 Maintain state-of-the-art skills through participation in in-service or other training

A.04 Participate in continuing education

A.05 Understand and apply continuous improvement principles (see Data Analysis)

A.06 Demonstrate knowledge of the business products/services

B. Communicating on the Job

B.01 Use effective written and other communication skills

B.02 Use telephone etiquette including relaying messages accurately

B.03 Employ appropriate skills for gathering and retaining information

B.04 Interpret written, graphic and oral instructions

B.05 Interact with co-workers and customers in a logical, clear and understandable manner

B.06 Use language appropriate to the situation

B.07 Participate in meetings in a positive and constructive manner

B.08 Use job-related terminology

B.09 Write technical reports, letters and memoranda as appropriate to the audience (e.g., management, customers, co-workers, and manufacturers)

B.10 Document work projects, procedures, tests, and equipment failures

C. Solving Problems and Critical Thinking

C.01 Identify the problem

C.02 Clarify purposes and goals

C.03 Identify available solutions and their impact including evaluating credibility of information, and locating information

Many instructors face the challenge of generating and maintaining students' interest during training. Relating electronics theory to products or components seen in everyday life should highlight the practical application of the material being taught and help to stimulate interest in the material.

C.04 Evaluate options

C.05 Set priorities

C.06 Select/implement options/decisions including predicting results of proposed action

C.07 Organize personal workloads

C.08 Participate in brainstorming sessions to generate new ideas and solve problems

D. Reading

D.01 Read and apply various sources of technical information (e.g., manufacturer literature, codes and regulations)

E. Proficiency in Mathematics

General

E.01 Determine if a solution is reasonable

E.02 Demonstrate ability to use a simple electronic calculator

Numbers and Number Relations

E.03 Round and/or truncate numbers to designated place value

E.04 Compare order and determine equivalences of real numbers (e.g., fractions, decimals, percentages)

E.05 Solve problems and make applications involving integers, fractions, decimals, percentages, and ratios using order of operations

E.06 Translate written and/or verbal statements into mathematical expressions

E.07 Compare, compute, and solve problems involving binary, octal, decimal, and hexadecimal numbering systems

Measurement

E.08 Convert, compare, and compute with common units of measurement within and across measurement systems

E.09 Read scale on measurement device(s) and make interpolations where appropriate

Data Analysis

E.10 Understand statistical terms and charts needed for interpretation of continuous improvement processes

E.11 Collect and organize data into tables, charts, and/or graphs

E.12 Interpret and use tables, charts, maps, and/or graphs

E.13 Identify patterns, note trends, and/or draw conclusions from tables, charts, maps, and/or graphs

E.14 Compute and interpret mean, median, and/or mode

Algebra

E.15 Simplify and solve algebraic expressions and formulas

E.16 Select and use formulas appropriately

E.17 Understand and use scientific notation

E.18 Use properties of exponents and logarithms

E.19 Determine slope, midpoint and distance

E.20 Graph functions

E.21 Use Boolean algebra to break down logic circuits

Geometry

E.22 Determine perimeters and areas of geometric figures

E.23 Determine surface areas and volumes of applicable geometric figures

E.24 Recognize, classify, and use properties of lines and angles

E.25 Recognize, classify, and use properties of two- and three- dimensional figures (e.g., circles, triangles, rectangles, cylinders)

E.26 Apply Pythagorean theorem

Trigonometry

E.27 Identify basic functions of sine, cosine, and tangent

E.28 Compute and solve problems using basic trigonometric functions

E.29 Graph basic functions using polar and/or Cartesian coordinate systems

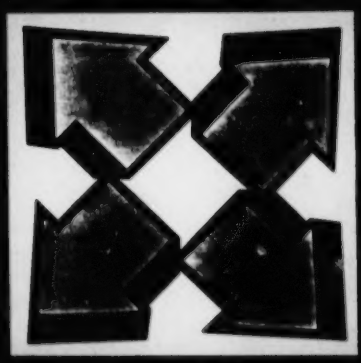
F. Proficiency in Physics

F.01 Understand fundamental principles of mechanics

F.02 Understand fundamental principles of pneumatics

F.03 Understand fundamental principles of hydraulics

F.04 Understand principles of electricity including its relationship to the nature of matter



Additional Skills

Three skill areas have been identified as having a sufficiently broad application in electronics to be included in the training of a work-ready, entry-level electronics technician, not at a detailed level but at a level that provides the technician with a basic overview and understanding of the subject matter. By having this basic understanding the technician will gain the ability at least to recognize, understand, and describe problems that may require expert assistance.

Included in Additional Skills are

A. Communications
B. Electromechanics
C. LASER Applications

Additional Skills

A. Communications

Estimated training time: 10 to 20 hours

A.01 Transmission line applications

A.02 Antenna systems

A.03 Types of multiplexing systems

A.04 Data communications

A.05 Types of telephone switching systems

A.06 Microwave communications systems

B. Electromechanics

Estimated training time: 50 to 75 hours

B.01 Servomechanisms, motors, and motor control circuits
- a. Power distribution systems
- b. Relays and relay circuits
- c. Protection circuits
- d. Types of motor controllers
- e. Types of motors

B.02 Hydraulic and pneumatic systems

B.03 Mechanical power transmission systems
- a. Measuring instruments
- b. Compound and reverted gear trains
- c. Internal and planetary gear trains
- d. Helical and bevel gear trains
- e. Rack and pinion mechanisms
- f. Worm and wheel mechanisms
- g. Block and screw mechanisms
- h. Counter rotating mechanisms and differentials, etc.

B.04 Vacuum systems and components

B.05 Mechanisms, linkages and levers

B.06 Transducers and instrumentation

B.07 Industrial materials

B.08 Automatic controls and robotics

C. LASER Applications

Estimated training time: 5 to 10 hours

C.01 Welding, cutting and drilling

C.02 Data recording and manipulation

C.03 Environmental testing and monitoring

C.04 Nondestructive testing

C.05 Measurement

C.06 Communications

C.07 Fiber optics and lasers

C.08 Lasers in medicine

C.09 Holography/interferometry